16-019

Method and Apparatus for Applying Optical Film to Glass

Field of the Invention

The present invention relates a method and apparatus for applying decorative tape to glass and, more particularly, the present invention relates to an automated method and apparatus for precisely applying a tape that gives the appearance of cut beveled glass to a glass plate.

Background of the Invention

Cut beveled glass is used for decorative purposes in a variety of applications, such as, in windows, doors, tables and mirrors. Cut beveled glass is expensive due to the substantial labor involved in creating the bevel. In addition, the process used to produce cut beveled glass tends to weaken the glass. It is necessary for glass manufacturers to use thicker, more expensive, glass when manufacturing beveled glass to ensure the outside edge of the bevel meets minimum thickness standards. Consumers and glass manufacturers tend to avoid cutting bevels in a pane of glass because of the high degree of difficulty associated with cutting the bevel into the glass.

Tempered glass is widely used in commercial and residential buildings. Tempered glass is hard and brittle, which makes it difficult to create a bevel on an edge of the glass.

U.S. Patent No. 4,192,905 to Scheibal describes a transparent strip of polymeric material used to imitate a beveled edge. The transparent strip has a wedge-shaped cross-section having an angle similar to a beveled edge. The transparent strip has adhesive on one side for affixing the strip to the glass to produce a beveled edge appearance.

U.S. Patent No. 5,840,407 to Futhey et al. describes an optical film for simulating beveled glass. The optical film has a structured surface for providing a simulated beveled appearance. The structured surface is formed of a plurality of spaced parallel grooves that form a plurality of facets that simulate beveled glass.

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Minnesota Mining and Manufacturing (3M) sells a tape that creates the effect of cut glass when applied to a glass surface under the trademark Accentrim™. One version of the Accentrim™ product includes a tape portion and a liner or backing that is removed before the tape portion is applied to a glass surface to create the appearance of a bevel. 3M advertising indicates that the Accentrim™ tape can be used on windows, doors, cabinetry, entertainment centers, bookcases, mirrors and other furniture. A hand tool offered by 3M may be used to apply the Accentrim™ tape to a surface on an existing household item.

U.S. Patent No. 6,202,524 discloses a glass workpiece locating system. The glass work piece locating system includes a stop that positions the glass workpiece substantially perpendicular to the direction of a conveyor. A sensor senses one of the side edges of the glass workpiece to determine the position of the glass workpiece.

The '524 patent also discloses, as prior art, a glass workpiece positioning system for a cutting table that utilizes an edge sensor for determining the precise location of the workpiece. A conveyor will transport a workpiece onto the cutting table into engagement with a stop, positioning the glass workpiece in an arbitrary location on the cutting table. An edge-detecting sensor will move across the cutting table until it has detected at least three edges of the workpiece. Detection of the three edges allows the precise orientation of the glass workpiece to be determined. The movement of the cutting head assembly is adjusted according to the specific positioning of the glass workpiece. The adjustment of the cutting head assembly generally requires a rotation of a coordinate system used to control movement of the cutting head to correspond to the orientation of the glass workpiece.

Summary of the Invention

The present invention concerns a method and apparatus for applying decorative tape to a glass sheet. The apparatus includes a tape dispenser that supports a roll of tape having a liner or backing. The tape dispenser separates the tape from the liner and applies the tape to a glass surface. The tape dispenser includes a frame, a tape spool, a drive roll,

a platen and a rewind spool. The tape spool, the drive roller and the rewind spool are rotatably mounted on the frame. The drive roller controls the length of tape that is unwound from the tape spool and that is applied to the glass surface. In the exemplary embodiment of the invention, the platen has an angular front end portion. The tape is separated from the liner when the tape is pulled around the angular front end portion of the platen. The tape spool, drive roller, platen and rewind spool define a path of travel from the tape spool around the drive roller, around the front end portion of the platen to the rewind spool.

Embodiments of the tape dispenser include features that enhance the tape dispenser's ability to accurately apply tape to a glass surface. For example, the tape dispenser includes a slip clutch tensioner between the tape spool and the frame. A sensor is coupled to the drive roller that measures the length of the tape that travels past the drive roller. A pressure roller is rotatably mounted to the dispenser frame by a pneumatic actuator. The pressure roller is configured to apply pressure to the tape as the tape is applied to the glass. A position sensor is coupled to the pressure roller for determining a distance between the dispenser and the glass. An optical sensor is coupled to the dispenser frame for detecting edges of the glass to determine the size, location and orientation of the glass. A motor is coupled to the rewind spool by a slip clutch tensioner.

In one embodiment, a tape scoring die is connected to the frame. The die is located along a path of travel between the tape spool and the platen. The die is configured to score the tape so that the tape can be applied to the glass in various decorative patterns.

The dispenser separates the tape from the liner and applies the tape to the glass surface. The dispenser's drive roller moves the tape and liner along the travel path to the platen. The liner is moved around the angular front portion of the platen to separate the liner from the tape. The tape is applied to the glass by applying pressure to the tape with the pressure roller. The liner is wound onto the rewind spool.

In alternative embodiments of the invention, the tape and liner are tensioned between the tape spool and the drive roller. The length of the tape that passes the drive

roller is measured. The tape is scored and the scored portion is removed before the tape is applied to the glass to create a decorative pattern. The distance between the platen and the glass is sensed by the sensor mounted to the pressure roller and the platen is moved to a predetermined distance above the glass in response to the sensed distance. The edges of the glass are detected with an optical sensor mounted on the frame of the dispenser to orient the tape dispenser with respect to the glass.

In one embodiment, the dispenser includes a cassette that allows the tape to be quickly loaded onto the dispenser. The cassette includes a cassette frame, a tape spool, a routing guide, a platen, and a rewind spool. The tape spool and the rewind spool are rotatably mounted to the cassette frame. The routing guide is selectively connectable to and removable from the frame. The platen is fixed to or is formed as part of the cassette frame. A path of travel is defined from the tape spool, around the routing guide, around a front end portion of the platen to the rewind spool.

In embodiments of the cassette, the routing guide is comprised of a plurality of pins that are selectively insertable into holes in the cassette frame. The pins hold the tape and liner such that the tape and liner become disposed around the drive roller when the cassette is attached to the dispenser. A roll of tape for creating the appearance of a bevel when applied to glass having a liner is disposed on the tape spool. The tape and the liner are disposed around a routing guide and only the liner is disposed on the rewind spool.

To load tape for creating the appearance of a bevel when applied to glass onto the dispenser with the cassette, a roll of tape is installed into the cartridge. The roll of tape having a liner is disposed on the tape spool. The tape and the liner are routed around the routing guide. The tape is separated from the liner near an edge of the platen. Only the liner is routed around the rewind spool. The cassette is attached to the frame of the tape dispenser. The routing guide is removed from the cassette such that the tape and the liner become disposed around the drive roller of the dispenser.

In one embodiment, the dispenser is included in an automated tape application system for separating the tape from the liner and applying the tape to a surface of a glass plate. The tape application system includes a table for supporting a glass plate. A gantry

42is mounted to the table such that the gantry 42is movable in a first direction along substantially parallel sides of the table. A dispenser actuator is mounted to the gantry 42such that the dispenser actuator is movable in a second direction along the gantry. A tape dispenser frame is mounted to the dispenser actuator such that movement of a linkage of the dispenser actuator causes the frame to move in a third direction and such that the dispenser frame is rotatable with respect to the gantry. An optical sensor is mounted to the tape dispenser for detecting points along edges of the glass plate to determine the position and orientation of the glass plate. A controller is coupled to the gantry, the dispenser actuator and the optical actuator for positioning and orienting the tape dispenser with respect to the glass plate.

The tape application system separates the tape from the liner and applies the tape to the glass surface. The glass plate is supported by the table. The location of the glass plate is detected by locating edges of the glass plate with the optical sensor. The tape dispenser separates the liner from the tape and dispenses a length of tape. The tape is applied to the glass by applying pressure to the tape. The dispenser is moved with respect to the glass plate along directions generally parallel to edges of the glass article to define tape patterns on the glass article.

Embodiments of the tape application system enhance the ability of the system to accurately dispense tape onto glass plates. For example, a distance between the platen and the glass is sensed and the platen is moved to a predetermined distance from the glass in response to the sensed distance. A pressure application wheel is mounted to the dispenser and is movable into engagement with the glass plate. Variations in thickness of the glass caused the pressure application wheel to move with respect to the tape dispenser. A position sensor is coupled to the pressure application wheel and the dispenser actuator. Movement of the pressure application wheel is sensed by the position sensor and communicated to the dispenser actuator to move the dispenser to a predetermined distance above the glass plate.

In one embodiment, the tape application system detects the location of the glass plate and positions and orients the dispenser with respect to the glass plate. An optical

sensor is mounted to the dispenser for sensing edges of the glass plate. The sensor is coupled to the gantry 42for positioning the dispenser with respect to the glass plate. A controller is coupled to the optical sensor, the gantry 42and the dispenser actuator for positioning and orienting the dispenser with respect to the glass plate. The dispenser is moved with respect to the glass plate to apply tape to the surface of the glass plate to define a decorative pattern on the glass plate.

The tape dispenser is located and oriented with respect to a corner of the glass plate. A location of a first point on an edge of a rectangular glass plate is sensed with the optical sensor. A location of a second point on the second edge is sensed with the optical sensor. A location of a third point on a second edge of the plate is sensed with the optical sensor. The location and orientation of a corner of the glass plate are calculated based on the sensed locations. The tape dispenser is located and oriented with respect to the corner of the glass plate.

In one embodiment, the gantry of the tape application system is rotatable with respect to the glass support table. The gantry includes a first carriage coupled to the first side of the table such that the first carriage is movable along the first side of the table. The gantry includes a second carriage coupled to the second side of the table such that the carriage is movable independently along the second side of the table. The gantry includes a support which extends over the top surfaces of the supporting table for movement with the first and second carriages. The support has a first end that is pivotally connected to the first carriage. The support includes a second end having a connection to the second carriage that allows rotation with respect to the second carriage and linear movement normal to the second carriage.

In one embodiment, the gantry 42includes a first motor coupled to the first carriage and a second independent motor coupled to the second carriage. The first carriage and the second carriage are driven by independent ball screws.

The disclosed tape dispenser feeds tape by precision metering the tape dispense amount regardless of liner stretch conditions. This is accomplished by placing the tape drive roller upstream of the tape and liner separation point. Because the tape drive roller

is placed upstream of the tape and liner separation point, liner stretch does not affect the length of tape applied to the glass. As such, fluctuations in ambient conditions or tape liner variations does not affect the length of tape applied to the glass.

The cassette used with the dispenser allows the tape to be changed very quickly. In addition, the cassette allows several widths of tape to be dispensed by the dispenser. The cassette can be used to change tape styles and sizes or additional cassette assemblies can be ready for reloading another roll of the same tape style.

Tape patterns that are applied to glass include a frame pattern that is achieved by abutting two wedge shaped tape ends on the glass surface and a "mitered" pattern achieved by aligning pointed ends of four pieces of tape. A large gap will cause a cosmetic defect and a short gap or interference will cause overlapping and improper adhesion of the tape liner. Variations in the gap are significantly reduced by maintaining a constant distance between the platen and the glass surface. This is accomplished by monitoring the distance from the platen to the glass surface with a position sensor coupled to the pressure wheel. The position of the platen above the glass is adjusted based on the sensed position to keep the platen a constant distance above the glass.

The non contact glass light registration feature of the disclosed tape application system provides a precise indication of the location and orientation of the glass. This allows the tape to be precisely applied to the glass plate.

Additional features of the invention will become apparent and a fuller understanding obtained by reading the following detailed description in connection with the accompanying drawings.

Brief Description of Drawings

Figure 1A is an elevational view of tape applied to a glass pane in a decorative pattern;

Figure 1B is an elevational view of tape applied to a glass pane in a decorative pattern;

Figure 2A is atop plan view of a length of tape having a pointed end portion;

Figure 2B is atop plan view of a length of tape having a pointed end portion;

Figure 2C is atop plan view of a length of tape having a flat end portion;

Figure 2D is atop plan view of a length of tape having a wedge shaped end;

Figure 2E is atop plan view of a length of tape having a wedge shaped end;

Figure 3 is a top plan view of a tape application system for applying a decorative tape to a surface of a glass plate;

Figure 4 is an perspective view of a tape application system for applying a decorative tape to a surface of a glass plate;

Figure 5 is a perspective view of a tape application system for applying a decorative tape to a surface of a glass plate;

Figure 6 is a schematic representation of a tape dispenser in accordance with the present invention;

Figures 7 and 7A is a perspective view of a tape dispenser mounted to motors that vertically position the dispenser and rotate the dispenser;

Figure 8 is a perspective view of a tape dispenser with a tape cassette removed;

Figure 9 is a perspective view of a tape cassette for use in a tape dispenser with a routing guide installed in the cassette;

Figure 10 is a perspective view of a routing guide for use with a tape cassette;

Figure 11 is a front elevational view of a tape dispenser with a tape cassette removed;

Figure 12 is a front elevational view of a tape cassette for use with a tape dispenser;

Figure 13 is a schematic representation a decorative pattern of tape;

Figure 14 is a front elevational view of tape pressed onto a glass pane by a pressure roller;

Figure 15A is a schematic representation of tape ends applied by a tape dispenser at a given distance from a glass plate;

Figure 15B is a schematic representation of a first tape end applied by a tape dispenser a first distance from a glass plate and a second tape end applied by a tape

dispenser a second distance from a glass plate;

Figure 16 is an enlarged perspective view of an actuator for removing portions of tape that are not applied to a glass pane from a tape liner and a pressure roller for applying tape to glass;

Figure 17 is a top plan view of a rectangular glass pane arbitrarily oriented with respect to a coordinate system;

Figure 18 is a top plan view of a tape application system for applying a decorative tape to a surface of a glass plate;

Figure 19 is a partial perspective view showing a connection of an end of a rail of a gantry to a carriage of a gantry;

Figure 20 illustrates an overview of a schematic of the control system for the tape dispensing unit;

Figures 21 and 22 are flow charts depicting processing performed by a computer and motion controller during application of tape to a glass surface;

Figures 23A-E are illustrations of rotary die patterns on a rotary die; and,

Figure 24 illustrates ends of two strips of tape separated by a tape chad on a tape liner.

Detailed Description of the Preferred Embodiments

The present disclosure concerns a system 10 for applying tape 12 having a liner 14 or backing to a glass pane 16 in a decorative pattern 18. Examples of decorative tape patterns 18 applied to glass panes 16 by the disclosed system 10 are illustrated in Figures 1A and 1B. The decorative pattern 18 depicted in Figure 1A creates the appearance of mitered glass. The decorative pattern depicted in Figure 1B is referred to as a frame pattern 20. The frame pattern 20 creates the appearance of a beveled edge on the sides of the glass pane.

The decorative patterns 18 are created by applying strips 22 of tape 12 to the glass pane 16. In the illustrated embodiment, ends 24 of the tape 12 are cut to mate with ends of other pieces of tape or with edges 26a-d of the glass pane 16. The ends 24 of the strips

22 of tape are applied to the glass in close proximity with one another to give the appearance of a continuous bevel. For example, the central ends 28 of the strips that form the decorative pattern 18 illustrated in Figure 1A are pointed and outer ends 30 are flat or squared off. Figures 2A and 2B illustrate pointed tape ends 32 that could be used to create the pattern illustrated by Figure 1A. Figure 2C illustrates a squared off end 34. The ends 24 of the strips that form the decorative pattern 18 illustrated in Figure 1B are wedge shaped. Figures 2D and 2E illustrate wedge shaped tape ends 36. A cosmetic defect occurs if there is too large a gap between the ends 24 of the strips 22 of tape or the ends of the tape overlap.

Referring to Figures 3 - 5, the disclosed tape application system includes a table 38 for supporting one or more glass panes 16 or plates, a tape dispenser 40, a gantry 42 for moving the tape dispenser 40 with respect to the table 38, and a controller 44 for controlling movement of the dispenser 20 and dispensing of the tape.

DISPENSER

Referring to Figures 6 and 7, the disclosed tape dispenser 40 includes a frame 46, a tape spool 48, a drive roller 50, a platen 52 having an angular front end portion 54 and a rewind spool 56. The tape spool 48, drive roller 50, platen 52 and rewind spool 54 defining a path of travel 58 from the tape spool 48, around the drive roller 50, around the front end portion 54 of the platen 52, to the rewind spool.

The illustrated dispenser 40 also includes a pressure application roller 62, first and second drive roller idler pulleys 64, 66, a rotary die 68, a rotary die engagement anvil 70, a liner rewind idler pulley 72 and the tape dispenser 40 also includes a chad removal actuator 63 for removing portions of tape 12 from the liner 14. A roll 60 of tape 12 having a liner 14 is carried by the tape spool 48. In the embodiment illustrated by Figure 6, the tape 12 having the liner 14 extends from the roll of tape 60 around the drive roller 50. The first and second drive roller idler pulleys 64, 66 hold the tape 12 and liner 14 in engagement with the drive roller 50. The tape 12 and liner 14 extend from the drive roller 50 past the rotary die 68. The rotary die engagement anvil 70 or roller selectively

pushes the tape 12 into engagement with the rotary die 68. The tape 12 and liner 14 extend from the rotary die 68 to the angular front end portion 54 of the platen 52. At or near the angular front end portion 54 of the platen 52, the tape 12 separates from the liner 14. The tape 12 extends substantially linearly into an area in which the pressure application wheel 62 can selectively engage the tape 12 to press the tape 12 onto the glass pane 16. The liner 14 extends around the angular front end portion 54 of the platen 52, around the liner rewind idler pulley 72 to the liner rewind spool 56. One acceptable rotary die is Glass Equipment Development part number 2-15945. One acceptable anvil is Glass Equipment Development part number 3-16349.

Referring to Figures 7, 8 and 9, the illustrated frame 46 includes a base member 74 and a cassette plate 76. The base 74 includes a motor mount plate 77 and an intermediate plate 79. Servo motors that drive the drive roller 50, the rewind spool 56 and the rotary die 68 are mounted to the motor mount plate 77. Referring to Figures 8 and 11, the drive roller 50, the pressure application wheel 62, the second drive roller idler pulley 66, the rotary die 68, and the rotary die engagement anvil 70 are mounted on the intermediate plate 79 of the base 74. One acceptable tape drive roller is Glass Equipment Development's part number 3-16206. One acceptable pressure roller is Glass Equipment Development's part number 3-16137.

Referring to Figure 12, the tape spool 48, the platen 52, the liner rewind spool 56, the first drive roller idler pulley 64 and the liner rewind idler pulley 72 are mounted to the cassette plate 76.

Referring to Figures 7 and 11, the base member 74 of the illustrated tape dispenser 40 includes standoffs 78 that correspond to mounting holes 80 in the cassette plate 76. The cassette plate 76 is mounted to the base member 74 with nuts 82 (Figures 7 and 7A) that hold the cassette plates 76 on the standoffs 78 in the illustrated embodiment.

Referring to Figure 11, the drive roller 50 is rotatably mounted to the base member 74. The drive roller 52 is coupled to a drive roller servo motor (not shown in Figure 11) that drives the drive roller 50.

Referring to Figure 11, the second drive roller idler pulley 66 is mounted to the

base member 74 by a linkage 84. The second drive roller idler pulley 66 is rotatably mounted on a first end 86 of the linkage 84. The linkage 84 is pivotally mounted to the base member 74 near a middle portion 88 of the linkage 84. A second end portion 90 of the linkage 84 is connected to a drive roller engagement actuator 92 that is mounted to the base member 74 of the frame 46. Movement of the drive roller engagement actuator 92 causes the linkage 84 to move the second drive roller idler pulley 66 into and out of engagement with the drive roller 50. When the idler roller is not engaged, tape loading and unloading is facilitated. One acceptable drive roller engagement actuator 92 is a Bimba #M020.50-DXP pneumatic actuator.

Referring to Figures 6, 8 and 11, the rotary die 68 is rotatably mounted to the base 74 of the frame 46. The rotary die 68 is driven by a servo motor 69 (see Figure 20). One acceptable servo motor 69 is Yaskawa's model number SGMAH-02. Referring to Figures 22A-E, the rotary die 68 includes a surface 94 with cutting patterns 96 defined thereon that score the ends of tape strips being dispensed. The cutting edges depicted in Figure 23A corresponds to the strip end shown in Figure 2A. The cutting edges depicted in Figure 23B correspond to the strip end shown in Figure 2B. The cutting edge depicted in Figure 23C, corresponds to the strip end depicted in Figure 2C. The cutting edge depicted in Figure 23D corresponds to the strip end depicted in Figure 2D. The cutting edge depicted in Figure 23E corresponds to the strip end depicted in Figure 2E. The pattern 96 shown in Figures 23A and 23B define bow tie-shaped cutouts or chads 112 on the tape 12 that are removed from the liner 14, which results in two strips 22 of tape 12 having pointed ends 32 (see Figures 2A, 2B). In the exemplary embodiment, the chad is removed prior to application onto the glass. Figure 24 shows a chad 112 on the backing 14 before it is removed. Referring to Figures 23D and 23E, the rotary die 68 includes patterns 96 that define wedge-shaped tape ends used in creating a frame pattern 20. Referring to Figure 23C, the surface 94 of the rotary die 68 also includes a rectangular pattern for creating squared off ends 34.

The rotary die engagement anvil 70 is connected to the base member 74 by a linkage 98. The linkage 98 is pivotally connected to the base member 74 at a pivot point

100. The rotary die engagement anvil 70 is rotatably connected to a first end portion 102 of the linkage 98. The linkage 98 is coupled to an actuator 106. Movement of the actuator 106 causes the rotary die engagement anvil 70 to selectively push the tape 12 into engagement with the rotary die 68. One acceptable actuator 106 is Bimba #M170.75-DQ. In the exemplary embodiment, when the actuator 106 is not engaged it is possible to load the tape cassette.

When a pattern 96 is to be scored into the tape 12 the rotary die 68 is rotated by the servo motor 69 to the beginning of a desired pattern to be scored into the tape 12. When the location on the tape to be scored reaches the rotary die 68, the actuator 106 moves the rotary die engagement anvil 70 to bring the tape 12 into engagement with the rotary die 68. As the tape 12 moves past the rotary die 68, the rotary die 68 is rotated by the servo motor 69 at the same speed as the tape to score the desired pattern 96 into the tape 12. The rotary die engagement anvil 70 is free wheeling and rotates as the tape 12 is scored by the rotary die 68.

Referring to Figure 6, a chad removal actuator 63 is mounted to the base member 74. The chad removal actuator 63 includes an engagement portion 110 that is extendable and retractable. When the rotary die 68 scores the tape 12 to define a pattern 96, the tape 12 is advanced until the chad 112 is located on the platen 52 below the engagement portion 110 of the chad removal actuator 63. The tape 12 is stopped. The engagement portion 110 is moved into engagement with the chad 112. In the exemplary embodiment, an adhesive is on the engagement portion 110 or the adhesive from a previously removed chad is exposed, causing the chad 112w to stick to the engagement portion 110. The end portion 110 of the chad removal actuator 63 is retracted to remove the chad 112 of tape 12 from the lining 14.

Referring to Figure 8, the pressure application wheel 62 is mounted to the base member 74 by an arm 114. A first end 116 of the arm 114 is pivotally connected to the base member 74. An actuator 118 (Figure 4) is connected to the arm 114 and the base 74. Movement of the actuator 118 causes the arm to move about pivot point 120 (Figure 11). One acceptable actuator 118 is SMC #NCDG-CN25-0100-B54L pneumatic actuator.

An engagement actuator 122 is connected to a second end 124 of the arm 114. The pressure application wheel 62 is rotatably connected to an end 126 of the engagement actuator 122. The engagement actuator 122 moves the pressure application wheel 62 with respect to the frame 46 of the tape dispenser 40 to press tape 12 onto a glass pane 16. A linear position sensor 128 is coupled to the engagement actuator 122. A signal from the linear position sensor 128 is used to position the tape dispenser 40 vertically with respect to the glass pane 16. One acceptable engagement actuator 122 is SMC #MXH16-30-A93L pneumatic actuator.

Referring to Figures 8 and 11, a rewind drive hub 130 is rotatably mounted to the base member 74. The rewind drive hub 130 is coupled to a DC motor 132 by a slip clutch (not shown). The rewind drive hub 130 is sized to fit within circular cavity 134 in the rewind spool 56 (see Figure 12). The rewind drive hub 130 drives the rewind spool 56. The DC motor 132 winds the liner 14 onto the rewind spool 56 and keeps the liner 14 taught. One acceptable motor 132 is a 24v DC motor.

Referring to Figures 9 and 12, the tape spool 48, the first drive roller idler pulley 64, the platen 52, the linear rewind idler pulley 72 and the rewind spool 56 are mounted to the cassette plate 76. These components mounted on the cassette plate are referred to as a cassette assembly 75. The tape spool 48 is mounted to the cassette plate 76 with a slip clutch tensioner 136. The slip clutch tensioner 136 keeps the tape 12 and liner 14 taught between the tape spool 40 and the drive roller 50. The first drive roller idler pulley 64 is mounted to the cassette plate 76, such that the first drive roller pulley 64 can rotate freely. The platen 52 is fixed to the cassette plate 76. The linear rewind idler pulley 72 is connected to the cassette plate 76, such that it may freely rotate. The rewind spool 56 is connected to the cassette plate 76, such that the rewind spool 56 can freely rotate.

Referring to Figures 9, 10 and 12, a routing guide 138 is used with the cassette assembly 75 to position the tape 12 and liner 14 around the drive roller 50 as the cassette 75 is assembled onto the base 74. The routing guide 138 includes four guide pins 140a-d connected to a mounting block 142. The four pins 140a-d correspond to four holes 144a-d in the cassette plate 76.

Referring to Figure 12, the tape 12 and liner 14 on the cassette 75 are routed from the roll 60 of tape 12 on the tap spool 48 around the first drive roller idler pulley 64. The tape 12 and liner 14 are routed from the first drive roller idler pulley 64 around the guide pins 140a-d. The tape 12 and liner 14 are routed from the routing pin 140d to the angular front end portion 54 of the platen 52. The tape 12 separates from the liner 14 at or near the angular front end portion 54 of the platen 52. The liner 14 is routed around the angular front end portion 54 of the platen 52 to the liner rewind idler pulley 72. The liner 14 is routed from the liner rewind idler pulley 72 onto the rewind spool 56.

Referring to Figures 6 and 11, the drive roller engagement actuator 92 and rotary die actuator 106 are retracted before the cassette 75 is assembled to the base member 74 to load the tape 12 and liner 14 onto the tape dispenser 40. Retracting the drive roller engagement actuator 92 moves the first drive roller idler pulley 64 away from the drive roller 50, allowing the tape 12 and liner 14 to be positioned between the drive roller 50 and the idler pulley 64. Retracting the rotary die engagement actuator 106 creates a space between the rotary die 68 and the rotary die engagement anvil 70 for the tape 12 and liner 14 to be positioned. The mounting holes 80 in the cassette 75 are aligned with the standoffs 78 in the base 74. The cassette plate 76 is then fastened to the standoffs 78 with the nuts 82. The rewind drive hub 130 on the base members 74 engages the rewind spool 56. The tape 12 and liner 14 is positioned around the drive roller 50 and between the rotary die engagement anvil 70 by the pins 140a-d of the routing guide 138. The routing guide 138 is removed from the cassette 75. The liner 14 and tape 12 becomes disposed around the drive roller 50. The drive roller engagement actuator 92 is extended to cause the second drive roller idler pulley 66 to move the tape 12 and liner 14 into contact with the drive roller 50. In the illustrated embodiment, the tape 12 and liner 14 are sandwiched between the drive roller 50 and the second drive roller idler pulley 66 when the drive roller engagement actuator 92 is extended. Slippage between the tape 12 and the drive roller 50 is inhibited by engaging the tape 12 and liner 14 between the drive roller 50 and second drive roller idler pulley 66.

During operation of the tape dispenser 40, the drive roller 50 pulls tape 12 and

liner 14 off the roll 60 on the tape spool 48 and feeds the tape 12 and liner 14 to the platen 52. The length of tape 12 and liner 14 provided by the drive roller 50 is monitored by monitoring operation of the servo motor 53 that drives the drive roller 50 and a signal provided by an encoder 146 (Figure 20) that is coupled to the drive roller 50. The DC motor 132 coupled to the rewind hub 130 causes the rewind spool 56 to rewind the liner 14. The DC motor 132 keeps the liner 14 between the platen 52 and the rewind spool 56 taught and the tape 12 and liner 14 between the drive roller 50 and the platen 52 taught. The engagement actuator 122 moves the pressure roller 62 into engagement with the tape 12 and presses the tape 12 onto a glass pane 16.

The tape dispenser 40 cuts the tape 12 into strips 22 that are applied to the glass pane 16. The rotary die 68 is rotated to the pattern 96 associated with the tape end 24 associated with a strip being applied. The rotary die engagement actuator 106 is extended to move the rotary die engagement anvil 70 to bring the tape 12 corresponding to an end 24 of a strip 22 being formed into engagement with the rotary die 68. The drive roller 50 advances the tape 12 and liner 14 while the rotary die 68 rotates to cut the desired pattern 96 into the tape 12 to create the ends of the tape strip. At this point, the strips 22 of tape to be applied to the glass pane 16 and a chad of tape 112 defined by the cut of the rotary die 68 that is not to be applied to the glass pane 16 are on the liner 14. After the rotary die 68 scores the desired pattern 96 into the tape 12, the rotary die engagement actuator 106 moves the rotary die engagement pulley 70 away from the rotary die. When the rotary die engagement pulley 70 is spaced apart from the rotary die 68, the tape 12 and the liner 14 pass the rotary die 68 without being engaged by the rotary die 68.

The tape 12 and liner 14 are moved to position the chad on the platen 52 beneath the chad actuator 108. The chad actuator 108 is extended to engage the chad 112 on the liner 14 and retracted to remove the chad 112 from the liner 14. In the exemplary embodiment, several chads of tape 112 are removed from the liner 14 with the chad actuator 108 before the chads 112 have to be removed from the end portion 110 of the chad actuator 108.

If the rotary die 68 cuts a relatively large pattern 96 in the tape 12, a portion of the

chad 112 could possibly reach the pressure application roller 62 before the chad of tape 112 is removed by the chad actuator 108. In the illustrated embodiment, the actuator 118 pivots the arm 114 away from the dispenser frame 46 to prevent the pressure application wheel 62 from pressing the chad of tape 112 onto the glass pane 16. The actuator 118 moves the arm 114 back to its original position after the chad of tape 112 is removed from the liner 14. In the exemplary embodiment, to prevent the leading chad points from contacting the glass, the dispenser is moved upward with respect to the glass pane a pre-determined amount prior to the chad points leaving the platen tip.

Referring again to Figures 3-5, the tape dispenser 40 is mounted above the table 38 for supporting one or more glass panes. The table includes a top 148 supported by a plurality of legs 150. In the illustrated embodiment, a plurality of slots 152 are included in the table top 148. A series of conveyors 154 are disposed in the slots 152 in the table. The conveyors are driven by an AC motor 155 (Figure 5). The conveyors 154 move a glass plate 16 placed at a first end of the table 38 toward a second end 158 of the table. In the exemplary embodiment, the glass pane 16 need not be aligned on the table top 148.

In the exemplary embodiment, vacuum cups (not shown) are included on the table top for holding the glass to the table. Acceptable vacuum cups are Anver number A-3150 078P vacuum cups. The vacuum cups are powered by a vacuum generator. One acceptable vacuum generator is Anver #JE30HDSE.

In the illustrated embodiment, the tape dispenser 40 is mounted above the table 38 by the gantry 42. In the illustrated embodiment, the gantry 42 is connected to the table 38. The gantry 42 includes a rail 160 mounted to a first side 162 of the table top 148 and a second rail 164 mounted to the second side 166 of the table top 38. A first carriage 168 is slidably mounted to the first rail 160. A first ball screw 170 (shown in Figure 3) is mounted within the first rail 160. The first ball screw 170 is coupled to the first carriage 168. A servo motor 172 is mounted to a first end 174 of the first rail 160. The servo motor 172 is coupled to the first ball screw 170. Actuation of the first servo motor 172 causes rotation of the first ball screw 170 which moves the first carriage 168 along the first rail 160. The rail 160, ball screw 170 and carriage 168 may be purchased as a unit.

For example, Star Linear's # MKK25-110 ball screw actuator includes a rail, ball screw and carriage base that may be used in accordance with the present invention. One acceptable first motor 172 is Yaskawa's model number SGMGH-09.

A second carriage 176 is slidably mounted to the second rail 164 of the gantry 42. A second ball screw 178 (illustrated in Figure 3) is mounted within the second rail 164. A second servo motor 180 is mounted to a first end 182 of the second rail. The second ball screw is coupled to the servo motor 180. Actuation of the servo motor 180 causes rotation of the second ball screw 178 which moves the second carriage 176 along the second rail 164 of the gantry 42. The first and second servo motors 172, 180 are connected to the controller 44, which controls actuation of the motors 172, 180 to move the carriages 168, 176 along the gantry 42rails 160, 164. In the exemplary embodiment, the actuation of the motors 172, 180 is synchronized to move the carriages 168, 172 along the rails 160, 164 in unison. The rail 164, ball screw 178 and carriage 176 may be purchased as a unit. For example, Star Linear's # MKK25-110 ball screw actuator includes a rail, ball screw and carriage base that may be used in accordance with the present invention. One acceptable second motor 180 is Yaskawa's model number SGMGH-09.

The first rail 160 includes first and second stops 184a, 184b. The first and second stops 184a, 184b are mounted near ends of the first rail 160 to prevent the first carriage from moving off the first rail. Similarly, stops 186a, 186b are mounted to the second rail 164 to prevent the second carriage 176 from moving off the second rail.

Referring to Figure 4, the first carriage 168 includes a base 188 and a top plate 190. The base 188 is slidably mounted to the first rail 160 and is coupled to the first ball screw 170. The top plate 190 is connected to the base 188 by a pivotable connection 192 that allows the top plate 190 to rotate about the pivotable connection 192 with respect to the base 188.

Referring to Figure 19, the second carriage 176 includes a base 194 an intermediate plate 196 and a top plate 198. The base 194 is slidably connected to the second rail 164 and is coupled to the second servo motor 180 by the second ball screw.

First and second linear bearings 200a, 200b each include a rail portion 202 and a channel portion 204 slidably connected to the rail portion. In the embodiment illustrated by Figure 19, the rail portion 202 of each linear bearing 200a, 200b is connected to a top surface 206 of the base 194 of the second carriage. The channel portion 204 of each linear bearing 200a, 200b is connected to a bottom surface 208 of the intermediate plate to slidably connect the intermediate plate 196 to the base 194. The intermediate plate is free to move transversely with respect to the base 194. The top plate 198 is connected to the intermediate plate 196 by a pivotable connection 210 that allows the top plate to rotate with respect to the intermediate plate 196.

Referring to Figures 3, 4 and 5, the gantry 42 includes a third rail 212 that extends between the first and second carriages. The third rail 212 includes a first end 214 that is fixed to the top plate 190 of the first carriage and a second end 216 that is fixed to the top plate 198 of the second carriage. A dispenser carriage 218 is slidably connected to the third rail 212. A third ball screw 220 (shown in Figure 3) is rotatably mounted within the third rail 212. A third servo motor 222 is mounted to a first end 224 of the third rail 212. The third servo motor 222 is coupled to the third ball screw 220. Actuation of the third servo motor 222 causes rotation of the third ball screw 220 which moves the dispenser carriage 218 along the third rail 212. The rail 212, ball screw 220 and carriage 218 may be purchased as a unit. For example, Star Linear's # MKK25-110 ball screw actuator includes a rail, ball screw and carriage base that may be used in accordance with the present invention. One acceptable third motor 222 is Yaskawa's model number SGMGH-09.

Referring to Figures 18 and 19, in the illustrated embodiment, the first and second carriages 168, 176 of the gantry 42 are moved independently by servo motors 172, 180. In the event that one of the first and second carriages 168, 176 binds up on one of the side rails 160, 164 of the gantry 42, the third rail 212 pivots with the top plates 190, 198 of the first and second carriages 168, 176 to prevent damage to the gantry 42. Referring to Figures 4, 18 and 19, when one end of the gantry 42 stops as a result of the binding and the second end of the gantry 42 continues to move along the rail, the third rail 212 and top

plate 190 of the first carriage 168 rotate with respect to the base of the first carriage 168. The third rail 212 and the top plate 198 of the second carriage 176 rotate with respect to the base 194 of the second carriage 176. In addition, the intermediate plate 196, top plate 198 and end 216 of the third rail 212 move along the linear bearings 200a, 200b toward the first rail. The pivotal connection between the first rail and the third rail 212 and the pivotal and slidable connection between the second rail and the second end of the third rail 212 allows the third rail 212 of the gantry to rotate if one of the carriages 168, 176 of the gantry 42 binds up, preventing damage to the gantry 42.

Referring to Figures 7 and 7A, the third rail 212 includes an upper portion 226 and a side portion 228 that includes an additional guide 230 or support. The dispenser carriage 218 is slidably mounted to the upper portion 226 of the third rail 212. A vertical rail 232 is connected to the dispenser carriage 218 by brackets 234. The vertical rail 232 is slidably connected to the guide 230. The vertical rail 232 and dispenser carriage 218 slide as a unit along the third rail 212 when the third ball screw 220 is driven by the third servo motor 222. The guide 230 stabilizes the vertical rail 32 and dispenser carriage 218 on the third rail 212.

Referring to Figures 7 and 7A, a vertical carriage 236 is slidably mounted to the vertical rail 232. A vertical ball screw 238 (not shown in Figures 7 and 7A) extends within the vertical rail 232. A vertical motor 240 is mounted to the top of the vertical rail 232. The vertical motor 240 is coupled to the vertical ball screw 238. Actuation of the vertical motor 240 causes rotation of the vertical ball screw 238 which moves the vertical carriage 236 along the vertical rail 232. The vertical rail 232, vertical ball screw 238 and vertical carriage 236 may be purchased as a unit. For example, Star Linear's # CKK-20-145 ball screw actuator includes a rail, ball screw and carriage base that may be used in accordance with the present invention. One acceptable motor 172 is Yaskawa's model number SGMAH-01.

Referring to Figure 6, the vertical carriage 236 includes an L bracket 244. First and second gas springs 246a, 246b are connected at one end to the L bracket 244 and at one end and to brackets 234 connected to the vertical rail 232. The gas springs 246a,

246b provide an upward force on the tape dispenser 40 to counterbalance the weight of the tape dispenser. The gas springs 246a, 246b reduce the amount of load carried by the vertical motor 240. The vertical motor pushes the dispenser 40 down against the force supplied by the gas springs 246a, 246b and pulls the dispenser 40 up with the assistance with the gas springs 246a, 246b. The gas springs 246a, 246b prevent the dispenser 40 from descending when power to the vertical motor 240 is lost.

Referring to Figures 7 and 7A, a rotary motor 248 is connected to the L bracket 244 of the vertical carriage 236. The rotary motor 248 is selectively actuated to the controller 44. The rotary motor 248 is coupled to a mounting plate 250 that carries the tape dispenser 40. The controller 44 provides signals to the rotary motor 248 that caused the rotary motor to rotate the tape dispenser 40. One acceptable rotary motor is Yaskawa's model number SGMPH-02.

Referring to Figure 11, the illustrated system includes an optical sensor 252 that is connected to the dispenser carriage 218. In the illustrated embodiment, the optical sensor 252 is mounted on the motor plate 79 of the tape dispenser 40. The optical sensor 252 senses edges of the glass pane 16 and provides an output to the controller 44. The output of the optical sensor 252 is used to calculate the location and orientation of the glass pane 16. One acceptable optical sensor 252 is a Keyence #FU-38 sensor.

Referring to Figure 17, the system 10 has a known home coordinate system 254 having an X axis and a Y axis. In the exemplary embodiment, glass panes are placed on the table 38 and moved into position by the conveyors 154. Typically, a corner 256 of the glass pane 16 is not aligned with the home coordinate system 254. The optical sensor 252 is used to determine the actual coordinate system 258 of the glass pane 16 that corresponds to the corner 256 of the glass pane. The optical sensor 252 is moved across the pane of glass 16 to locate points along edges 26a-d of the glass pane 16. The detected points along the edges of the glass pane 16 can be used to determine the location and orientation of the actual coordinate system 258 that corresponds to a corner 256 of the glass pane 16, as well as the size of the glass pane 16.

For example, the optical sensor 252 is moved along the Y axis of the home

coordinate system 254 a given distance D1. The optical sensor 252 is then moved in the X direction of the home coordinate system 258 until an edge 26a of the glass pane 16 is detected. The home XY coordinates are recorded as point 1. The optical sensor 252 is then moved along the home coordinate system 254 X axis a second given distance D2. The optical sensor 252 is then moved along the Y axis until an edge 26b is detected by the optical sensor 252. The home XY coordinates of this position are recorded as point 2. The optical sensor 252 is moved along the X axis of the home coordinate system 258 a given distance D3. The optical sensors 252 is then moved along the Y axis until an edge 260b of the glass plate 16 is detected by the optical sensor 252. The XY coordinate of this location is recorded as point 3. Using the XY coordinates of the detected points 1, 2 and 3, the actual coordinate system 258 that corresponds to the corner 256 of the glass pane 16 is calculated.

In one embodiment, the optical sensor 252 is used to determine the overall dimensions of the glass. Two more points along edges of the glass pane 16 are required to determine the location, orientation and size of the glass pane 16. Points 1-3 are sensed as described above. The optical sensor 252 is moved along the X axis the given distance D2 and then moved along the X axis until a fourth edge 26d of the glass pane 16 is detected. The XY coordinates of the detected location are recorded as point 4. The optical sensor 252 is moved along the Y axis the given distance D2. The optical sensor is moved along the X axis until a third edge 26c of the glass pane 16 is detected by the optical sensor 252. The XY coordinates of this location are recorded as point 5. Points 1-3 are used to calculate the actual coordinate system corresponding to the corner 256 of the glass pane 16. The distance between points 1 and 5 and the orientation of the actual coordinate system are used to calculate the width of the glass. The orientation of the actual coordinate system and the distance between points 2 and 4 are used to calculate the height of the glass.

Referring to Figures 13, 14 and 15, the engagement actuator 122 that carries the pressure roller 62 includes a linear position sensor 128. The linear position sensor 128 senses the position of the pressure application wheel 62 relative to the tape dispenser 40.

A signal is provided by the linear position sensor 128 to the controller 44. When the pressure application wheel 62 is in engagement with the tape 14 and the glass pane 16, the signal provided by the linear position sensor 128 provides an indication of the distance d1 between the glass pane and the tape dispenser 40. The signal provided by the linear position sensor 128 is processed by the controller. The controller causes the vertical motor 240 to move the tape dispenser 40 to a specified distance above the glass pane 16. One acceptable linear position sensor 128 is Northstar #PELMIX3-02.5-101.

Variations in thickness of the glass pane 16 or variations in the flatness of the table top change the distance d1 between the tape dispenser 40 and the glass pane 16. In the exemplary embodiment, the linear position sensor 128 continually provides a signal to the controller 44. The controller 44 controls the vertical motor 240 to maintain the tape dispenser 40 at a specified distance above the glass pane 16.

Figure 13 illustrates four strips 22 of tape 12 applied to a glass pane 16. Inconsistencies in the point to point gap 262 between the pointed ends of the strips 22 create cosmetic effects. For example, if the point to point gap is too large, it will be readily apparent to an observer that the glass is not beveled. A reduction in the point to point gap could result in overlapped tape segments.

Figure 14 illustrates the effect of variations in thickness of the glass 16 on the application of strips 22 of tape 12 to the glass 16. Figure 14 shows that the pressure application wheel 62 presses a different portion of tape 12 onto the glass 16 depending on the distance between the tape dispenser 40 and the glass pane 16. Figure 15A shows the point to point gap G between ends 24 of tape 12 applied where the distance between the tape dispenser 40 and the glass pane 16 is constant. Figure 15B shows the point to point gap G^1 between ends 24 of a first strip and a second strip where the dispenser 40 and glass pane 16 was the first distance and a tape end 24b that was applied when the tape dispenser 40 was farther away from the glass pane 16 as indicated by the phantom lines in Figure 14 when the end of the second strip was applied to the glass 16. As is shown in Figures 14 and 15, an increase in the distance between the tape dispenser 40 and the glass pane 16 between the application of two ends 24 of tape strips 22 increases the gap

between the tape ends 24. Similarly, if the distance between the tape dispenser 40 and the glass pane 16 decreases between the time the end of a first strip 22 of tape 12 is applied to the glass 16 and an end of a second strip 22 of tape 12 is applied to the glass 16, the point to point gap between the strips 22 decreases. The linear position sensor 128 allows the controller to maintain the tape dispenser 40 at a specified distance above the glass pane 16 to minimize variations that result from variations in distances between the tape dispenser 40 and the glass pane 16. Maintaining a minimum distance between the dispense head and glass surface achieves consistent point to point gaps. In testing a distance of approximately 0.050" has proven consistent results. At this distance the chad points could contact the glass and be pressed by the pressure roller. In the exemplary embodiment, the controller calculates when the chad points are near the glass, and signals the z-axis actuator to lift.

CONTROLLER OPERATION

Figure 20 illustrates a schematic of a control system 300 for controlling a number of motors included in the tape dispensing system10. A computer 302 is coupled to a network (not shown) and is most preferably a specially programmed personal computer running an operating system compatible with network communications. The computer 302 receives a schedule indicating the patterns of tape to be applied to multiple pieces of glass. These pieces may all be of a particular size or they may be the pieces for a particular job, order or customer. The schedule is generated by a separate computer that is coupled to the computer 302 depicted in Figure 20 by means of a network interface. A user interface 304 for the computer in Figure 20 constitutes a touch panel screen and keyboard which allows an operator of the tape dispensing system 10 to control operations of the system.

A two way serial communications link 306 exists between the computer of Figure 20 and a motion controller 44 specially programmed for co-ordinated energization of a number of motors and receipt of a number of input signals derived from various sensors located within the tape dispensing system. One acceptable controller is a Delta Tau

UMAC motion controller having a twenty-one slot chassis. The computer 302 transmits control signals to the motion controller 44 for each pane of glass that is to be taped by the tape dispensing system. Thus, the computer receives a schedule from a remotely located computer, evaluates that schedule, and sends a set of controls to the motion controller for each pane of glass until all panes in the schedule have been taped.

The motion controller 44 interfaces with a number of motor drives 310, 312, 314, 316, 318, 320, 322, 324, 326, 328 for different motors used in the system. These motors position the tape dispenser 40 above a horizontal surface which supports a glass pane or lite. The motors also control various actions performed by the tape as the tape dispenser 40 moves relative to the glass. Three direct current servo motors 172, 180, 222 coupled to the gantry 42 control the position of the tape dispenser 40 in an x-y plane above the glass. Two motors designated gantry motor 172 and gantry 42 motor 180 are energized by the controller in a coordinated fashion with each other to move the gantry 42 back and forth. A third motor designated gantry motor 222 moves the tape dispensing unit across the horizontal support 212 extending over the glass. These motors are servo motors activated with a direct current signal in either of two directions. Coordinated energization of these motors positions the tape dispenser 40 during tape dispensing as well as positions the tape dispenser prior to application of tape to the glass.

A separate feature of the invention is sensing glass orientation (described above). These motors 172, 180, 222 also drive the tape dispenser 40 relative to the glass so that an optical sensor 252 mounted to the dispenser can determine the glass orientation. The optical sensor communicates signals by means of an input to the motion controller. Additional inputs that are used by the motion controller are discussed below.

An additional motor 240 moves the tape dispensing unit up and down to change the gap or spacing between the tape dispenser and the glass. This motor 240 is also a direct current servo motor for allowing the tape dispenser to be moved up and down. During operation of the system 10 , a piece of glass to be taped is delivered by means of a v-belt conveyor system to a position relative to a home position of the tape dispenser 40. The belt drive of the this conveyor is operated by an alternating current drive motor 155

whose operation is also controlled by the motion controller. In the exemplary embodiment, the alternating current drive operates in two directions and delivers the glass for taping, and then subsequent to taping drives the glass from the surface of the table in the same direction of motion used to deliver the glass to the table. In an alternate embodiment, the alternating current drive delivers the glass for taping and then subsequent to taping drives the glass from the surface of the table in the opposite direction of motion used to deliver the glass to the table. The glass orientation is monitored by the motion controller and in response to this indication, the controller knows the angular direction with respect to a system axis it needs to move the tape dispenser for appropriate application of tape to the glass.

The tape dispenser is also mounted for rotation about a vertical axis through a range of 210 degrees. Since the tape dispenser unit always dispenses tape in the same direction that is dictated by the orientation of the platen 52, by reorienting the dispenser, the tape can be applied along any direction and specifically, a direction controlled by the angular orientation of the glass as it is delivered to a position on the table 38. The angular orientation of the tape dispenser 40 is controlled by a head rotation motor 248 which also constitutes a direct current servo motor which can be driven in either direction.

A pressure wheel is brought into contact with the tape as it is being dispensed from the tape dispenser 40. The location of the wheel is controlled by a pneumatic actuator 92 that raises and lowers the pressure wheel into and out of contact with the tape. Initially, as the end of the tape is being fed from the unit, and separated from the liner or backing, the pressure wheel is removed from the glass surface to allow the tape to contact the glass and adhere to that glass prior to engagement of the pressure wheel. At various points during application of the tape, the tape is cut or scored to define the two ends of a piece of tape. Application of multiple such pieces of tape defines the appearance of the finished lite.

A rotary die contains multiple dies and is driven by a motor 69 that is controllably energized to position an appropriate die in relation to an anvil or backing for the die so

that when the anvil is moved into position an appropriate pattern is scored into the tape. The rotary die motor 69 also constitutes a direct current servo motor which allows the die to be oriented and then rotated during movement of the tape once the anvil has been moved into position for scoring.

As tape is being delivered to the glass, a drive motor 53 is responsible for pulling the tape from the tape spool 48 and a rewind motor 130 is responsible for rewinding the backing material after the tape has separated from the backing material in the region of the platen and is applied to the glass. The tape drive motor 53 is a direct current servo motor which unwinds the tape from the spool 48 and delivers it to the region where it separates from its backing or liner. One acceptable tape drive motor is Yaskawa model number SGMAH-01. The liner take up motor 130 is a DC servo motor that is coupled to a take up reel by a clutch mechanism to allow the liner to be rewound onto a take up reel subsequent to application of the tape to the glass. When the tape is not being applied to the glass, the clutch mechanism allows the motor 130 to continuously rotate the wheel and apply a tension to the liner material.

Figures 21 and 22 are flow charts depicting processing steps performed by the computer 302 and the motion controller 44 during application of tape to a glass surface. In an automatic mode of operation depicted in Figure 21, the personal computer 302 shown in Figure 20 gets a schedule 330 by means of a network connection and interprets 332 that schedule to determine the sequence of controls to be sent to the motion controller. A first pattern is sent 334 to the motion controller by means of the bi-directional communications link 306 shown in Figure 20. This control constitutes an ASCII file containing control points for application of the tape to the glass as well as cut patterns to be used for the tape as it is being cut at its ends.

Once a particular pattern of tape pieces has been completed 336 as indicated by a signal from the controller 44, the computer awaits receipt of a signal that an operator has pressed a transfer enable button to move the pane from the table upon which it rests. The computer then determines 338 whether all patterns have been completed. If not, a next pattern is obtained 340 and a next subsequent control sequence sent to the motion

controller 44. Once all patterns have been completed, the computer stops 342 the transmission and awaits further schedules from the network computer.

In a so-called semi-automatic mode of operation, the operation of control system is the same except that an operator must press a region on the user interface 304 labeled 'cycle start' at which point the next schedule or program of tape dispensing is sent to the motion controller. In a manual mode of operation, automatic operation is disabled. In this manual mode, maintenance personnel can verify all the individual operations that are performed by the motion controller 44 in a co-ordinated fashion in automatic mode. In manual mode the user interface presents control options that the user activates by means of the touch sensitive screen to cause the various motors to be energized. For example the tape dispenser 40 can be moved up or down or rotated by the user by tapping on the screen. This causes the various motors to be actuated in a jog mode which briefly energizes that motor.

Receipt of a control pattern from the personal computer causes the motion controller to execute a process 344 shown in Figure 22. The data is received 346 from the personal computer and this causes the controller to position the gantry and orient the tape dispenser 348 in an appropriate position for the piece of a glass awaiting to be taped. The controller then sets the head spacing 350 between the glass and the tape dispenser as well as retracting the pressure wheel away from the glass surface. Movement of the tape dispenser in coordinated fashion while unwinding tape from the supply causes the tape to be applied 352 to the glass surface and once this process begins, the motion controller brings the pressure wheel against the tape after it has contacted the glass. Application continues until an end position for the tape is reached at which point the end of the tape is cut 354. Depending upon the cut pattern, a discarded chad may remain in contact with the liner or backing which supports the tape as it is unwound from the supply. If this chad is present, it must be removed 356 from the backing and if it is not present due to the configuration of the cut applied to the tape, the head is lifted away 358 from the glass and moved to a new location. If a chad is removed, an actuator moves a capture device 108 into contact with the tape just downstream from the die prior to lifting of the head

away 358 from the glass. The controller moves the tape dispensing unit to a new location and lowers 360 the head in preparation of applying tape at a next location. As noted, prior to this step, a pressure wheel is retracted 362 until an end of the tape is applied to the glass at which point the pressure wheel is brought into contact with the tape on the glass. This process continues until all pieces of tape have been applied to the glass for the particular pattern at which point the controller sends a signal to the personal computer indicating a schedule for a next subsequent piece of glass is needed. The controller therefore sits in an endless loop awaiting for instructions from the personal computer so long as power is applied to the system.

Listing 1 is a sequence of steps in pseudo-code for motion program control to for a cross pattern wherein tape pieces extend across a pane to the pane's center region to form a cross.

Listing 1

Open and clear program buffer
Set Absolute position mode
preload U-axis position to 0
Pre-position A-axis for next required cut
Check if last die used on previous pattern is different that the first die required on current pattern. If it is different then make initial tap cut for first component.
    Prepare the A-axis (die) for cutting at the desired location
    Turn on the liner take-up motor
    Feed Tape and Cut
    Turn off liner-take up motor
    Pick Chad and move X,Y and C to the starting position for the component
Apply Component
    Touch off glass to check for variation in table top height, adjust Z-axis if necessary
    Turn on the liner take-up motor
    Feed tape to glass
    Lower Roller
    Pre-position A-axis (die) for required end of component cut
    Prepare the A-axis (die) for cutting at the desired location
    Move X Y position to end point of the component and cut tape on the fly when the tape is at the desired location
    Turn off the take-up motor
    Pick chad and move X,Y, C to the starting position of the next component
Repeat for all components in the pattern.

End of Listing 1

A number of sensors located throughout the system send signals back to the motion controller. Additionally, output signals are transmitted from the controller to solenoids for activating certain motions such as movement of an anvil 70 for backing the cutting die 68. Table 1 below indicates various input/output connections 306 utilized by the motion controller 44 and/or personal computer 302 during operation of the tape dispenser.

Table 1

Proximity switches	X-axis home and maximum and minimum overtravel
Proximity switches	X' axis home and maximum and minimum overtravel
Proximity switches	Y axis home and maximum and minimum overtravel
Proximity switches	Z-axis home and maximum and minimum overtravel
Proximity switches	C-axis home and maximum and minimum overtravel
Proximity switch	A-axis home
Amplifier drive	seven servo motors
E-stop button	Removes all power from controller
Master Start	resets controllers
Transfer ready button	Signals machine that the operator is ready to receive the glass at the exit side when the pattern is complete. Must be pressed for every pane.
Pause button	Pauses motion when pressed. All outputs remain in current state.
Cycle Start	Starts motion program resident in motion controller
Cycle stop	Cancels current pattern. Motion will decelerate to a stop. Dispenser returns to starting position of pattern
Mode switch	Manual/Semi-Auto or Auto Selector PC interface

Manual Glass Transfer	Operator moves glass PC interface
Pressure Switches	Machine Air OK, Vacuum ON
Linear Encoder	Tape off glass, relative positioning of head to glass feedback distance.
Reed Switches, verify positions	Anvil up/down, pressure roller forward, back, up, down, v-belt up/down
Photo-eyes	Glass on table, tape spool empty
Lamps	Pause, Cycle Start, Master Start
Solenoids	Anvil, Roller forward, Roller Down, Vacuum on, V-belt up/down,
Motor outputs	V-belt motor, blower motor

SYSTEM OPERATION

In operation, a pattern, such as those depicted in Figures 1A and 1B, and a size of a glass pane 16 is selected and inputted into the computer. The personal computer sends a series of signals to the motion controller by means of a bidirectional communication connection for processing the glass pane 16. Referring to Figure 3, a glass panel6 is placed on the table top 148. The conveyors 154 move the glass pane 16 to a location that is near the home coordinate system. Typically, the glass pane 16 will not be aligned with the home coordinate system. In the exemplary embodiment, the controller 44 provides signals to the servo motor 172, 180 and 222 to move the tape dispenser 40 and optical sensor 252 over the glass pane 16.

Referring to Figure 17, the tape dispenser 40 and optical sensor 52 are moved by the gantry 42 to detect a first point along edge 26a of the glass pane 16, and second and third points along edge 26d of the glass pane 16. The detected points P1, P2, P3 are processed by the computer to determine the actual coordinate system 258 that corresponds to the corner 256 of the glass pane 16.

The controller 44 causes the gantry 42 to position the tape dispenser 40 with

respect to the actual coordinate system 258 of the glass pane 16. Referring to Figures 4 and 5, the controller 44 provides a signal to the vertical servo motor 240 that causes the vertical servo motor 240 to move the dispenser 40 down from a most elevated position. The dispenser 40 is spaced apart from the glass pane 16 by a relatively large distance at this point. The controller 44 provides a signal to the engagement actuator 122 that causes the engagement actuator 122 to bring the pressure application wheel 62 into engagement with the glass pane 16. The linear position sensor 128 provides a signal to the controller 44 that indicates the distance between the tape dispenser 40 and the glass pane 16. In response, the controller 44 provides a signal to the vertical servo motor 240 that moves the tape dispenser 40 to a desired distance above the glass pane 16 for dispensing tape 12 onto the glass pane 16.

Referring to Figure 6, the controller 44 provides a signal to the drive roller 50 that causes the dispenser 40 to begin dispensing tape 12. The pressure application wheel 62 is lifted from the glass pane 16 momentarily as an end 24 of a strip of tape 22 is paid out by the dispenser 40. The pressure application wheel 62 is moved into contact with the tape 12 to press the end 24 of the strip 22 of tape 12 onto the glass pane 16. The controller 44 causes the gantry 42 to move with respect to the coordinate system 258 of the glass pane 16 and the drive roller 50 to dispense tape 12 to create a decorative pattern 18 on the glass pane 16. During application of tape strips 22 onto the glass pane 16, the linear position sensor 128 continually provides a signal back to the controller 44 that indicates the position of the tape dispenser 40 with respect to the glass pane 16. In response, the controller 44 controls the vertical servo motor 240 to maintain the selected distance between the glass pane 16 and the tape dispenser 40.

When a second end of a strip 22 being applied to the glass pane 16 is about to be applied, the controller 44 provides a signal to the rotary die 68 that causes the rotary die 68 to rotate to a selected pattern that will be scored into the tape 12 corresponding to an end 24 of a tape strip 22. The dispenser 40 continues to apply tape 12 to the glass pane 16. When the tape 12 that corresponds to a second end of the tape strip 22 reaches the rotary die 68, the rotary die engagement actuator moves the rotary die engagement anvil

70 into contact with the liner 14. The rotary die engagement anvil 70 presses the tape 12 into engagement with the rotary die 68. The drive roller 50 continues to dispense tape 12, the rotary die 68 rotates the same speed as the dispensed tape 12 and the gantry 42 continues to move the dispenser 40 over the glass pane 16.

After a pattern 96 corresponding to the end 24 of the strip 22 is scored into the tape 12, the tape 12 is advanced until a chad 112 of tape that is not be applied to the glass pane 16 is located beneath the chad actuator 108. The controller 44 stops the gantry 42 from moving the dispenser 40 and stops the drive roller 50 from advancing the tape 12 and liner 14. The chad actuator 108 is extended to bring an adhesive surface on the chad actuator 108 or a previous adhesive surface on a previously removed chad into contact with the chad on the tape 112. The chad actuator 108 is retracted to pull the chad of tape 112 from the liner 14.

If the chad of tape 112 is large enough that an end of the chad would be pressed onto the glass 16 by the pressure application wheel 62 before the chad is removed from the liner 14, the controller 44 provides a signal to the actuator 118 that rotates the arm 124 to move the pressure application wheel 62 away from the end of the chad. In the illustrated embodiment, to prevent the chad points from touching the glass, the z-axis could lift as the chad reaches the platen. The actuator 118 moves the pressure application wheel to its original position after the chad is removed.

After the chad 112 is removed from the liner 14, the controller 44 causes the drive roller 50 to dispense tape 12 and the gantry 42 to move the tape dispenser 40 over the glass pane 16. The drive roller 50 dispenses tape 12 and the gantry 42 moves the dispenser 40 over the glass pane 16 until the second end 24 of the strip 22 of tape 12 is applied to the glass pane 16 by the pressure application wheel 62. After the strip of tape 12 is applied to the glass pane 16, the controller 44 sends a signal to the vertical servo motor 240 that raises the tape dispenser 40 with respect to the glass pane 16.

The controller 44 causes the gantry 42 to move the dispenser 40 to a location above the glass pane 16 where the next strip 22 of tape 12 will be applied to the glass pane 16. The process is repeated until all strips 22 that make up the pattern applied to the

glass pane are applied.

Many modifications and variations of the invention will be apparent to those skilled in the art in light of the foregoing disclosure. Therefore, it is to be understood that, within the scope of the appended claims, the invention can be practiced otherwise than has been specifically shown and described.